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AUTHOR Custers, Eugene J. F. M.; And Others
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ABSTRACT

The goal of this study was to investigate whether expert physicians' knowledge can be represented in the form of illness scripts. The idea of "scripts" was introduced by Schank and Abelson (1977) to explain why people are able to bring to bear enormous amounts of knowledge almost effortlessly in practical real-life situations. Previous script-related research has revealed that recognition memory discrimination for typical script items is generally poor. An experiment was designed to investigate whether this result would also apply to illness scripts, and whether level of expertise would influence recognition memory for illness script items. Though a significant interaction between typicality and textual presence of items was found for experienced physicians (n=23) but not for fourth-year medical students (n=22), no clear developmental trend could be discerned; the intermediate group of sixth-year medical students (n=20) appeared to have a more accurate recognition memory than either the experts or the novices. The results are discussed with regard to the development of illness scripts. One table and two figures present study findings. An appendix contains a case example. (Contains 20 references.) (SLD)

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A Recognition Study in Support of the Psychological Validity of Illness Scripts

Eugène J.F.M. Custers, Henny P.A. Boshuizen, &
Henk G. Schmidt
University of Limburg, Maastricht, The Netherlands

Paper presented at the Annual Meeting of the American Educational Research Association,
New Orleans, LA, April 4-8, 1994

Correspondence address:
P.O. Box 616
6200 MD Maastricht
The Netherlands
phone: 0-11-31-43881109
E-mail: Custers@educ@rulimburg.nl

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Abstract

The goal of the present study was to investigate whether expert physicians' knowledge can be represented as illness scripts. Previous script-related research has revealed that recognition memory discrimination for script typical items is generally poor. An experiment was designed to investigate whether this result would also apply to illness scripts, and whether level of expertise would influence recognition memory for illness script items. Though a significant interaction between typicality and textual presence of items was found for experienced physicians but not for 4th-year students, no clear developmental trend could be discerned: the intermediate group (i.c., 6th-year students) appeared to have a more accurate recognition memory than either the experts or the novices. The results are discussed with regard to the development of illness scripts.

The representation of knowledge in general, and medical expert knowledge in particular, is a rather controversial issue. Part of this controversy arises from the fact that for different purposes it is useful to represent medical knowledge at different levels of description. Though few would disagree that neurons are somehow involved in human medical cognition, it is also obvious that the possibilities to describe and explain expert behavior at a neural level are still rather remote at the moment. Descriptions of expertise at a much higher level, for example in terms of experience, insight, or pattern recognition, may cover any expert behavior, but at the expense of offering no guidelines at all about how to improve expertise or to optimize its development by designing instruction or education. Therefore, most researchers have tried to apply psychological theories of an intermediate level to human expert behavior. In the 1960s and 70s, these theories heavily emphasized the distinction between the knowledge base and problem solving methods (e.g., Newell & Simon, 1972). As by the end of the 1970s it became clear that expert physicians could not be distinguished from nonexpert physicians on formal aspects of the problem solving process (e.g., Elstein, Shulman, & Sprafka, 1978), and that the essence of expertise is inherent in the structure of expert knowledge, theoretical interest shifted toward the way knowledge can be represented. Psychological theories that address this issue of knowledge representation, and therefore can be applied to expert medical cognition, are, among others, ACT* (Anderson, 1983), SOAR (Newell, 1990), the script theory (Schank & Abelson, 1977) and mental models (Johnson-Laird, 1983).

The present research is based on the assumption that expert medical knowledge, at least the clinical part of it, can be represented as a large set of illness scripts. The idea of "scripts" was introduced by Schank and Abelson (1977) to explain why people are able to bring to bear enormous amounts of knowledge almost effortlessly in practical real-life situations. A script is a cognitive structure that refers to a body of knowledge associated to a sequence of events that occurs frequently in a specific order (Fayol & Monteil, 1988; Schank & Abelson, 1977). As scripts guide inferencing during comprehension, their structure can be conceived as a set of concepts interrelated by firmly established excitatory links, with inhibiting connections to concepts that do not fit script-based expectancies. Thus, as a consequence of script activation, a whole set of concepts becomes automatically activated, even if no specific information about the individual members of this set is available yet.

In 1984, Feltovich and Barrows applied the notion of script to the medical domain.. However, from their point of view, illness scripts are structures

more like mental models than like the original Schank and Abelson scripts. For example, they define illness scripts as representations that need to be constructed for each patient on basis of biomedical knowledge. But subsequent research has revealed that expert physicians do not seem to rely that much on biomedical knowledge (e.g., Boshuizen & Schmidt, 1992). However, an important asset of the Feltovich and Barrows' illness script was the distinction between Enabling Conditions (contextual and patient-related factors that influence the probability that someone gets a disease) and Consequences (complaints, signs, and symptoms of a disease). Experts' illness scripts are ready-made packages of knowledge about Enabling Conditions and Consequences of diseases; these packages can be activated quickly in practical situations: thus, they can probably be described as script-like structures.

Evidently, it is not easy to prove that knowledge is represented in the form of scripts. However, script theory and script related research have generated some predictions that have received empirical support. For example, if a script is activated, e.g., by reading a text, the typical concepts associated with that particular script are also activated automatically. This activation is independent of the actual appearance of those concepts in the text. Consequently, it has been found that items or concepts that are very central or typical with respect to an activated script, but are never explicitly mentioned, have a rather high chance of being falsely recognized in a recognition test (e.g., Maki, 1990; Smith & Graesser, 1981; Walker & Yekovich, 1984). In this case, it is difficult for subjects to determine whether the activation of a concept is due to its actual presentation in a text or whether it is only implicitly inferred, i.e., activated by links with other, actually stated concepts. Atypical items, on the other hand, can only be activated by reading them in the text and tagging them to the activated script, as this atypical information does not fit in a specific script slot (Graesser, Woll, Kowalski, & Smith, 1980; Graesser & Nakamura, 1982). Thus, recognition decisions for atypical items can be made quickly: all the subject has to do is to check whether there is a tag in memory for that item. Typical or central concepts, on the other hand, usually receive no specific tag in memory, even if they are explicitly mentioned. Therefore, memory discrimination is often reported as better for atypical, explicitly stated items than for typical, explicitly stated items (cf. Bellezza & Bower, 1981; Smith & Graesser, 1981; Yekovich & Walker, 1986).

The present study was designed to investigate whether these characteristics of "real-life scripts" also apply to illness scripts. For example, would subjects be inclined to erroneously recognize patient characteristics or symptoms that might be expected given a particular disease, but are in fact not mentioned, or mentioned in other wordings, in a case? Arkes and

Harkness (1980) found evidence for false recognition of disease consistent but unstated symptoms, provided that the diagnosis was known to the subjects. Another question is whether recognition measures might reveal differences between the scripts of experienced physicians and those of medical students. As yet, research on this topic suggests that advanced students' illness scripts are more diffuse, with links between concepts less well established, and with the appropriate values to fill in slots less well circumscribed, than physicians' illness scripts (Custers, Boshuizen, & Schmidt, 1992; Custers et al., in preparation). Thus, it might be expected that the predicted effects of typicality and textual presence of information on recognition measures are less conspicuous for nonexpert subjects. Consequently, in an actual recognition experiment, students would show relatively good recognition memory for unstated, but script-prototypical statements, while experienced physicians would make relatively many errors on this type of items.

An experiment was designed to test these hypotheses. Case descriptions were presented to subjects of different expertise levels, followed by a set of recognition statements. These recognition statements had either been literally presented in the case or not, and they could be prototypical or atypical for the particular disease. Thus, typicality and textual presence were independently manipulated. The influence of this experimental manipulation on recognition measures was investigated. It was predicted that an interaction would be found between typicality and textual presence, with unstated prototypical statements showing comparatively high false alarm rates. In addition, a three-way interaction between expertise level, typicality and textual presence would be expected, with experienced subjects generally showing particularly poor memory discrimination for unstated, prototypical items.

METHOD

Subjects

Subjects were 22 fourth-year students, 20 sixth-year students, and 23 experienced family physicians. The forth-year students had followed a four year curriculum of theoretical and practical medical education, but they had virtually no clinical experience. They were tested at the end of the term. The sixth-year students had completed at least 75% of their clerkships, and therefore had walked the wards for 16 months or more. All student subjects were from University of Limburg at Maastricht, The Netherlands.

The experienced physicians were recruited from general practitioners in

the Maastricht area. They had on the average 16.25 years experience as practicing family physicians, ranging from 5.75 years to 41 years.

Material

From a set of 24 diseases used in previous research (Custers, Boshuizen, & Schmidt, 1993), nine were selected to be included in the present study. These diseases were: aneurysm of the aortic artery, herpes zoster, nervous abdominal pain, dermatitis peri-oralis, pre-infarct syndrome, vaginal candidiosis, epidural hematoma, kidney stones colic, and carcinoma of the head of the pancreas. Based on these afflictions, computerized case descriptions were constructed. Each case consisted of a number of statements, ranging from 15 to 24, which provided information about the patient's context and background, the setting (e.g., consultation hour, emergency telephone call, house call), the main complaints, and some symptoms. Though each case described a quite "textbook-like" patient, it also included some atypical patient characteristics and symptoms, while on the other hand some highly typical aspects of the disease were deliberately omitted. Appendix A shows an example of a case description.

For each case, a set of ten test statements was constructed. Five of these statements were exact copies of statements that appeared in the case description. The remaining five statements differed, at least as far as the wording concerned, substantially from any statement that appeared in the case. These types of statements will be called "stated" and "unstated", respectively. Both categories of statements were further divided into three prototypical items and two atypical items. The prototypical items contained information that was completely typical for the disease the case description was based upon, information that could be either stated or unstated. The atypical items, on the other hand, contained information that was not very typical for the disease in question. Thus, for example, atypical-unstated items were statements about patient contextual factors or disease characteristics that were neither very typical for the disease in question, nor literally mentioned in the case presentation. Figure 1 shows the organization of the test statements. Thus, in all there were three prototypical-literally stated items, three prototypical-unstated items, two atypical-literally stated items, and two atypical-unstated items; and these ten items were divided over four Enabling Conditions and six Consequences. Appendix A shows the test statements that were presented for the kidney stones colic case.

Figure 1. Overview of the ten test statements for each case

	prototypical	atypical
stated	1 Enabling Condition 2 Consequences	1 Enabling Condition 1 Consequence
unstated	1 Enabling Condition 2 Consequences	1 Enabling Condition 1 Consequence

Procedure

Subjects were tested individually, the students at the university department, the family physicians in their own office. Each experimental session consisted of a study task, an interim task and a test task. Both the study task and the test task were presented on a Macintosh Plus computer screen, and written in and controlled by Authorware. The interim task was not related to any of the other task; its role was simply to clear the subject's short-term memory.

After a short general introduction, the study task was started. The nine case descriptions were presented successively. Before each case was started, the name of the disease associated to that case was displayed on the screen. Subjects were encouraged to ask questions if they did not know the announced disease, or were in doubt about any aspect of it. If everything was clear, they could start the case presentation by pressing a button on the keyboard. Upon starting the case, the statements successively appeared on the screen. Each statement remained visible for a fixed time. This display duration was determined by the formula:

$$t=[1500 + 35 \bullet \text{number of text characters}] \text{ msec}$$

In previous research, it was found that subjects process this type of statements at a rate of approximately 35 milliseconds per text character. For purposes of the present study, we took a base rate of 1500 milliseconds per statement, supplemented with 35 milliseconds for each text character. The base rate of 1500 milliseconds was determined empirically in a pilot study,

and it resulted in a display time for each statement that was neither too short for the inexperienced subjects, nor too long for the expert physicians to process the presented information. Consequently, it might be assumed that every subject had sufficient time to read and comprehend each statement, but not enough time to memorize it.

Subjects were instructed to read each case as attentively as possible and to try to assimilate as much of the presented information as they could. All nine cases were presented successively; after completing each case presentation, an opportunity for remarks, questions or a short pause was provided. Subjects were not allowed to write anything down. Although the experimenter announced in the introduction that afterwards a task, based on the present cases, would be presented, the true nature of this task was of course not revealed in advance to the subjects.

After finishing the study phase a short interim task was presented, in which subjects were asked to tell something about medical journals they were familiar with (e.g., their content, the quality of the articles, their practical utility, the subject's preferences). The duration of this task was about 2-3 minutes.

Next, the test task was administered. For each case, subjects were shown the ten test statements, one by one. The set of test statements associated to each individual case was always presented as a block, with the individual statements appearing in an order that was randomly determined, but fixed in advance. Subjects were instructed to decide as accurately and as quickly as possible for each individual statement whether it had been *literally* presented in the original case presentation or not. In order to answer this question, a press-button device, until that moment carefully hidden from subjects' view, was connected to the computer. This device contained two buttons, the left one labeled "yes", the right one labeled "no". Subjects were instructed to press the "yes" button if they judged a particular test item as having been literally presented in the case, and "no" if they judged that this had not been so.

It was emphasized that the test statements had either been literally presented in the associated case, or were considerably different from any statement in any case, at least in wording. However, it was also stressed that a particular test statement could be very similar in meaning to an item in the case, but that this meaning should not be taken into consideration, as their task was only to judge the literal presence of the statements.

Before each block of statements associated to a case was presented, the name of the disease the case was based on was again announced on the screen, in order to reinstate the proper illness script context. The sequence of the cases in the test session was the same as in the study session. Between

each block of case test items, also an opportunity for questions or a short pause was provided. After the test phase was finished, subjects were debriefed and received a small reward for their participation.

Analysis

Every time a subject pressed a button, the selected response ("yes" or "no") was registered. The first case was a practice case and its results were not included in the analysis. For the remaining eight cases, average number of "yes" answers computed for each of the ten different types of test statements (see Appendix A). Thus, this procedure yielded ten "yes/no" measures for every subject, based on the eight instances of each test statement type. In fact, this measure can also be conceived as ten scores on a nine-point recognition scale, each score ranging from zero (a "no" answer for each of the eight instances of a given statement type) to eight (eight times a "yes" answer for each of the eight instances of a given statement type). However, in order to account for the fact that the test task for each case included three prototypical statements of both types and only two atypical statements, the percentage of "yes" answers for each statement type was used, rather than the raw number. Subsequently, these percentage values were analyzed with a three (levels of expertise) by two (prototypical versus atypical) by two (textual presence, or: stated versus unstated) analysis of variance, with expertise level as between subjects factor and typicality and textual presence as within subjects factor.

RESULTS AND DISCUSSION

The results showed a significant main effect of expertise level [$F(2, 62) = 5.348$, $p < .001$, $MS_e = 297.510$], a significant main effect of typicality [$F(1, 62) = 35.138$, $p < .0001$, $MS_e = 66.738$], and a significant main effect of textual presence [$F(1, 62) = 772.052$, $p < .0001$, $MS_e = 269.940$]. Furthermore, significant two-way interactions between textual presence and expertise [$F(2, 62) = 6.053$, $p < .005$, $MS_e = 269.940$] and between typicality and textual presence [$F(1, 62) = 17.183$, $p < .0001$, $MS_e = 54.988$] were found, but no significant interaction between typicality and expertise. Finally, the results showed a significant three-way interaction between expertise, typicality and textual presence [$F(2, 62) = 5.496$, $p < .01$, $MS_e = 54.988$]. The results are depicted in Table 1.

From Table 1, it can be read that the main effect of expertise level can be accounted for by the 4th-year students generally positively "recognizing" relatively more statements than the 6th-year students or the family physicians. The main effects of typicality and textual presence are relatively straigthforward: over all expertise levels, prototypical statements more often receive a "yes" answer than atypical statements (55.58% vs. 49.52%), and stated items are of course more often recognized than unstated items (80.71% vs. 24.39%). Figure 2 shows the interaction effects. Most interesting two-way interaction in light of the illness script theory is the one between typicality and textual presence. Generally, i.c. over the three expertise levels, explicitly stated items are recognized about equally well, regardless whether they are prototypical or atypical, while unstated items are more often falsely recognized if they are prototypical than if they are atypical. However, the finding of a significant three way interaction between expertise level, typicality and textual presence indicates that the interaction between typicality and textual presence is not alike for all expertise levels. The illness script theory predicts that this latter interaction should be accounted for mainly by the results of the family physicians; Figure 2 shows that this prediction is borne out: for 4th-year students, the interaction is absent, while for family physicians, it is evidently present. Thus, family physicians show a relatively stronger inclination to falsely recognize unstated prototypical items, compared to unstated atypical items, than subjects at less advanced levels of medical expertise, while for stated items, there are no differences between the three expertise levels with regard to their relative recognition scores for prototypical versus atypical items.

These results support to a large extent the hypothesis that illness scripts are indeed script-like structures in the sense of Schank and Abelson (1977), though not all predictions could be confirmed. Support was found for the hypothesis that items in line with a specific illness, but never explicitly

Table 1. Average percentage of positively recognized statements ("yes" answers) for three expertise levels and different types of statements

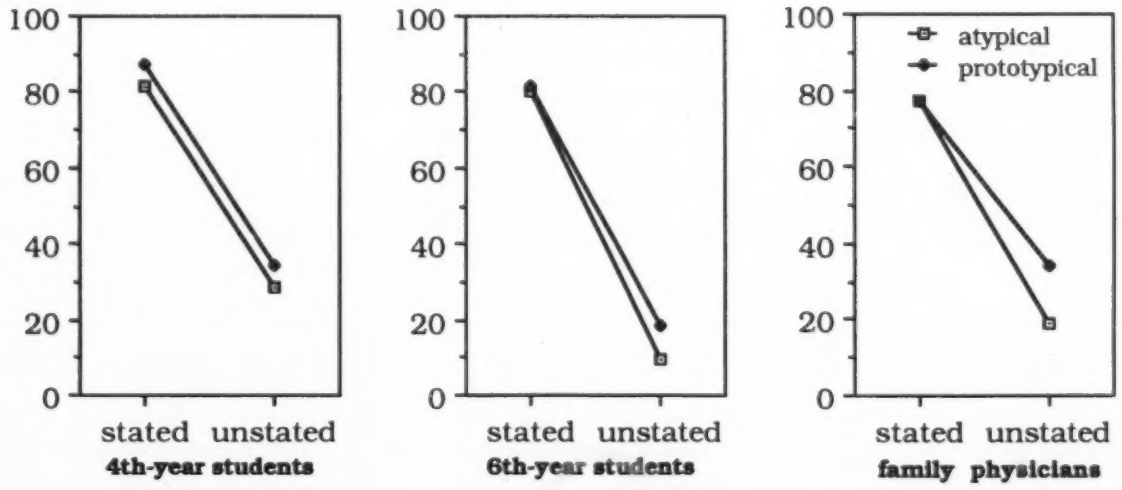
	stated		unstated	
Expertise level	P	A	P	A
4th-year students	87.12	81.53	34.66	28.69
6th-year students	81.46	80.00	18.33	9.38
family physicians	76.99	77.45	33.88	19.29

Note — P=prototypical, A=atypical

presented, show a relatively high probability of being falsely recognized, compared to statements that are less likely, given the particular script. Generally, atypical information did show somewhat better memory discrimination than prototypical information if it was unstated, but not if it was stated. This might be a consequence of the nature of the type of information: the atypical items could be considered neutral or uninformative, rather than salient or contradictory. As a consequence, though actually presented, they may have received no specific tag, and thus may not have been sufficiently activated.

It could be argued that the results of the three-way interaction do not give an accurate impression of the real differences between the expertise groups, as in fact the 4th-year students falsely recognized an about equally high percentage of unstated, prototypical items than the family physicians (34.66% vs. 33.88%). However, unlike the family physicians, the fourth year students showed a high proportion of false recognitions of atypical unstated items also (28.69% vs. 19.29%), a finding that would not be expected, should their knowledge be structured in illness script format. The tendency of recognition accuracy for prototypical, stated items to decrease with increasing expertise level (from approximately 87% for 4th-year students to 77% for family physicians) might be explained by assuming that reading a prototypical statement increases its activation level in less experienced subjects, while this level is already elevated to a maximum in experienced subjects as a result of the script activation (cf. Graesser & Nakamura, 1982). Consequently, it would

Figure 2. The effect of typicality and textual presence on positive recognition percentages at different levels of expertise.



be more difficult for experienced subjects to decide whether there had indeed been an external activational source — i.e., a text statement presented on the screen — for a stated prototypical item, in addition to the "internal" script-based activation.

Inspection of Figure 2 reveals that, like so many expertise research in the medical field, the present study also did not escape from finding an intermediate effect. For the unstated items, the 6th-year students performed better than both the less and the more experienced subjects, for atypical as well as for prototypical statements. As this effect was found for unstated, but not for stated items, it is difficult to explain: it cannot be accounted for by the hypothesis that 6th-year students are generally more accurate, or show better memory for the actually presented data, than either 4th-year students or expert family physicians.

In conclusion, evidence was found that some of the characteristic recognition features of scripted texts apply to a large extent also to illness scripts, and that the results showed a developmental tendency from relative novices to relative experts, with the data of the latter group being more in line with general script research findings than the data of the former group.

Finally, although it is difficult to derive recommendations for actual medical education from this particular study, we want to emphasize that support for the notion that medical, especially clinical, expertise can be represented as illness scripts, also includes support for the educational consequences of this view, as outlined in related, recent work (Custers et al., 1992; Custers et al., in preparation). Perhaps the most important of these recommendations includes that students should be provided with ample opportunities to form illness scripts by seeing as many patients as possible, especially with frequently occurring diseases, and with an emphasis on an accurate representation of the actual normal variation in Enabling Conditions as well as Consequences.

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APPENDIX A

Example of a case description and the associated test statements

case: kidney stones colic

1. Man, aged 47
2. He is married and has three teenage children
3. His occupation is store-keeper
4. At age 30, he was treated for bronchitis
5. Six years ago, he had his leg broken as a consequence of a car accident
6. Four years ago, he was treated with medicaments for kidney stones
7. Some of his relatives are known with coronary diseases and diabetes mellitus
8. His wife rings up, asks the physician for an immediate visit: it's happening again
9. Her man is vomiting almost continuously
10. He is rolling across the room because of the pain
11. At the moment the physician arrives, the pain has just subsided
12. The patient is sitting on the sofa, recovering a bit
13. He complains about having had a convulsive abdominal pain at the left side, abreast of the navel
14. The pain extends to his groins
15. The pain emerged all of a sudden, and then gradually subsided
16. During an attack, he almost can't stand it
17. Earlier that day, he had already seen some blood in his urine
18. But he had no pain at that time
19. His wife says she has measured a temperature of 38.2 degrees Centigrade

Testitems (the actual order of the items in the test was randomly determined):

Typ[1]	Pres[2]	Script[3]	Item text
P	S	EC	Man, aged 47
P	S	Con	He is rolling across the room because of the pain
P	S	Con	The patient is sitting on the sofa, recovering a bit
P	U	EC	Four years ago, he had a kidney stone colic
P	U	Con	The pain radiated
P	U	Con	In-between the attacks, he doesn't look very ill
A	S	EC	Six years ago, he had his leg broken as a consequence of a car accident
A	S	Con	Earlier that day, he had already seen some blood in his urine
A	U	EC	He is slightly overweight
A	U	Con	He has a mild fever

[1] Typ= item typicality (P=prototypical, A=atypical)
[2] Pres= textual presence (S=stated, U=unstated)
[3] Script= script component (EC=Enabling Condition, Con=Consequence)